Performance Analysis of Delay Tolerant Networking

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Project Goal

The goal for this research project is to understand the performance behavior of routing in delay tolerant networks (DTN) in order to develop more efficient algorithms to route messages in DTN environments. In our research we identified three performance parameters of DTN routing and used simulation analysis to collect statistics on these parameters for two popular DTN routing protocols. As part of the effort, we developed four variations of the routing algorithms for one of the popular DTN routing protocols.

Background

In traditional computer networking, the path between the source and destination is known prior to the message leaving the source node. Delay Tolerant Networking (DTN) is a type of communication technology that is designed to forward messages in scenarios where the end-to-end path doesn't necessarily exist at the time the message is originated or forwarded.

There a few routing protocols used in DTN environments, the simplest being the Epidemic protocol. In Epidemic, a node with a message will forward the message to all nodes it encounters, similar to the spread of a disease in a population. Probabilistic Routing Protocol using History of Encounters and Transitivity (PRoPHET) is another type of routing protocol. PRoPHET uses past encounters to predict future routes. Each node estimates a 'p' value for all other nodes, where the 'p' value represents the estimated probability of a message being delivered to that node.

Project Description

PRoPHET provides a framework to estimate probability of message delivery, leaving open the possibility of using different forwarding decision algorithms. We developed four ways by which the PRoPHET model can be used to decide the best next hop node for a given message. The four algorithms are represented in the following table:

Forwarding Condition / Hop Limit	**Pe > Pp** Pe is the P value for the encountered node and Pp is the P value of the previous node to which the message was forwarded	**Pe > Ps** Pe is the P value of the encountered node and Ps is the P value of self, the node making the forward decision
2 Hop Limit -Message source is allowed to forward to intermediary nodes if the forwarding condition is met -Intermediary nodes can only deliver to destination	**Type 1**	**Type 2**
No Hop Limit -Message source and intermediary nodes are allowed to forward to other nodes if the forwarding condition is met	**Type 3**	**Type 4**

Simulation Analysis

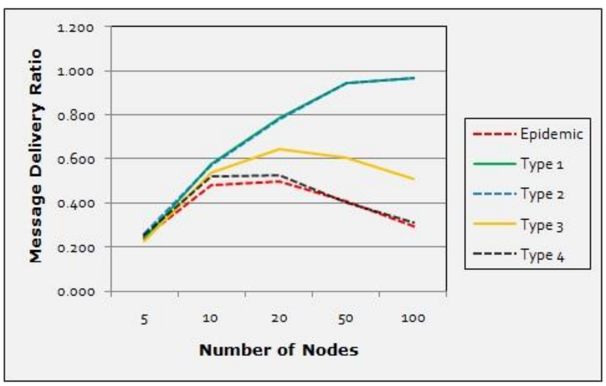
These 4 algorithms and epidemic routing algorithm were implemented into the Opportunistic Network Environment (ONE) simulator and extensive simulation experiments were conducted to test the performance of each of these algorithms and the Epidemic routing protocol. We identified the following three performance parameters:

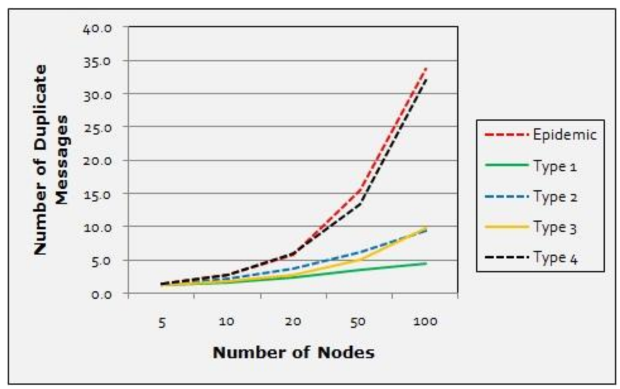
- **Message delivery ratio.** Ratio between the number of messages successfully delivered and the number of messages that were created in a given simulation experiment.
- **Average latency.** The average amount of time taken for messages to be delivered successfully.
- **Average number of duplicate messages.** The average number of messages that are still floating around the network at the time of the first delivery

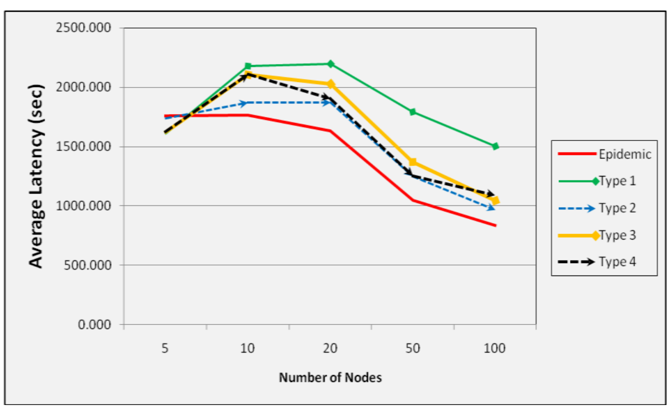
The simulation experiment was conducted with the following parameters:

- Simulation area of 4500m x 3400m
- Nodes moving based on random waypoint mobility model
- Randomly selected source and destination for 500 messages
- Multiple experiments with different number of nodes in the network

The following graphs represent the results from our simulation experiments.







Our results show that the algorithms that are conservative in making copies (Type 1 and 2) have a higher percentage of delivery as they do not clog up the queues in all the nodes by creating a large number of duplicate messages. They perform better in terms of both the message delivery ratio and the average number of duplicate messages. However, the average latency of message delivery is high for these conservative algorithms in comparison to more aggressive algorithms like Type 3, 4 and Epidemic.